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# POISONING OF WILDLIFE WITH ANTICOAGULANT RODENTICIDES IN NEW YORK

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ABSTRACT: From 1971 through 1997, we documented 51 cases (55 individual animals) of poisoning of non-target wildlife in New York (plus two cases in adjoining states) (USA) with anticoagulant rodenticides—all but two of these cases occurred in the last 8 yrs. Brodifacoum was implicated in 80% of the incidents. Diphacinone was identified in four cases, bromadiolone in three cases (once in combination with brodifacoum), and chlorophacinone and coumatetralyl were detected once each in the company of brodifacoum. Warfarin accounted for the three cases documented prior to 1989, and one case involving a bald eagle (*Haliaeetus leucocephalus*) in 1995. Secondary intoxication of raptors, principally great horned owls (*Bubo virginianus*) and red-tailed hawks (*Buteo jamaicensis*), comprised one-half of the cases. Gray squirrels (*Sciurus carolinensis*), raccoons (*Procyon lotor*) and white-tailed deer (*Odocoileus virginianus*) were the most frequently poisoned mammals. All of the deer originated from a rather unique situation on a barrier island off southern Long Island (New York). Restrictions on the use of brodifacoum appear warranted.

*Key words:* Anticoagulant rodenticide poisoning, brodifacoum, bromadiolone, *Bubo virginianus*, *Buteo jamaicensis*, diphacinone, great-horned owl, *Odocoileus virginianus*, raptor, red-tailed hawk, white-tailed deer, wildlife.

## INTRODUCTION

Anticoagulant poisons interfere with the action of vitamin K in the production of clotting factors in the liver, and thereby kill by predisposing animals to fatal hemorrhage. They are presently the most commonly-used pesticides for the control rodent pests world-wide. The first anticoagulant synthesized for use as a pesticide was the coumarin-based compound warfarin, introduced in the 1940's (Osweiler et al., 1985). Other coumarin-based rodenticides were subsequently developed, as were indandione compounds like diphacinone which show similar anticoagulant activity. Emergence of rat populations with resistance to warfarin and some of the other early anticoagulants eventually led to the development of more potent compounds like brodifacoum and bromadiolone which, unlike the older compounds, will kill rodents after single feedings.

Toxicity data for a variety of domestic animals (Osweiler et al., 1985), suggest that anticoagulant rodenticides are no doubt a potential hazard to many wild mammals and birds. The degree of hazard would be expected to vary by compound, species, and type of application. Poisoning could occur by direct ingestion of bait (primary poisoning), or via consumption of poisoned rodents (secondary poisoning). Potential for the latter was demonstrated by Evans and Ward (1967) who fed anticoagulant-killed nutria (*Myocastor coypus*) to dogs and commercial mink, by Mendenhall and Pank (1980) who fed rats and mice killed with a variety of rodenticides to owls, and by Townsend et al. (1984) who fed warfarin-dosed mice to least weasels (*Mustela nivalis*).

In the United States, applications of brodifacoum in apple orchards resulted in the deaths of radio-marked screech owls (*Otus asio*) (Hegdal and Colvin, 1988). Littrel (1988) reported the diphacinone-caused deaths of a raccoon (*Procyon lotor*) and a mountain lion (*Felis concolor*) at a site in northern California under unknown circumstances. More recently, two barn owls were killed by brodifacoum near a poultry farm in Georgia (USA) in 1995 (C. F. Quist, pers. comm.).



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In the UK, Shawyer (1987) reported a "mass mortality" involving tawny owl (*Strix aluco*), buzzard (*Buteo buteo*), magpie (*Pica pica*), and red fox (*Vulpes vulpes*) which followed baiting with brodifacoum at a Hampshire farm in 1981. Shawyer (1987) also reported suspected poisonings in barn owls (*Tyto alba*) associated with the use of brodifacoum (four cases), difenacoum (four cases) and bromadiolone (one case) between 1982 and 1985. Subsequently, about 10% of 145 barn owls found dead in Britain between 1983 and 1989 were found to contain detectable (>0.005 ppm) levels of brodifacoum, although only one owl was considered to have succumbed to poisoning (Newton et al., 1990). In France, a four-year study of possible anticoagulant poisonings of wildlife (Berny et al., 1997) yielded 59 confirmed diagnoses for bromadiolone and 41 for chlorophacinone. Twenty-eight animals, principally red foxes and buzzards, were recovered from a single area near the Swiss border where bromadiolone was applied to carrot baits for the control of voles (*Arvicola terrestris*). Similar use of bromadiolone in Switzerland itself was followed by a large kill of buzzards and kites (*Milvus milvus*). Several unspecified predatory mammals also were killed (Beguin, 1983 and Pedrolic, 1983, cited in Shawyer, 1987). In Malaysia, barn owls were reportedly decimated when brodifacoum and coumachlor replaced warfarin on a palm oil plantation (Duckett, 1984). In New Zealand, one magpie, one paradise duck (*Tadorna ferruginea*), two unidentified hawks, two unidentified gulls, one unidentified passerine, and one unidentified hare were found dead following experimental use of brodifacoum to control rabbits (*Oryctolagus cuniculus*) (Rammell et al., 1984). Other reports of avian mortality linked to brodifacoum use in New Zealand have been reviewed by Eason and Spurr (1995).

Given the experimental evidence, the magnitude of rodenticide use, some of the reports cited above, and our own data, we suspect that the poisoning of wildlife in the United States with anticoagulants is far more common than the published record suggests. The purpose of the present paper is to report both primary and secondary poisoning of non-target wildlife with anticoagulant rodenticides in New York (USA) from 1971 through 1997.

## METHODS

Most of the cases included in this report were submitted for diagnosis directly or indirectly by the general public. Wildlife rehabilitators also contributed a significant number of specimens. When necropsies showed hemorrhage or anemia in the absence of traumatic injury or infectious or parasitic disease processes, the livers were collected, frozen, and shipped to an analytical laboratory. Analyses were completed at the New York State Police Laboratory (Albany, New York) prior to 1977, and subsequently at the WARF Institute and its successor, Raltech Scientific Services (Madison, Wisconsin, USA), through 1984. Since then, analyses were completed at the State of Illinois Animal Disease Laboratory (Centralia, Illinois, USA) using a high-performance liquid chromatography screening procedure. This method utilized a solid-phase cleanup to prepare small-sized samples (2g) for analysis (Chalermchaikit et al., 1993). Identification and quantitation of the 11 different anticoagulant rodenticides in the screen were achieved by reverse-phase separation using both UV and fluorescence detectors (Shimadzu models SPD-6AV and RF-535, Shimadzu Scientific Instruments, Inc., Columbia, Maryland, USA) in tandem to facilitate both the primary and confirmatory analysis (J. R. Stedelin, unpubl. data). When needed, particularly with indandione compounds, additional sensitivity and confirmation were attained with an ion-pairing method (Hunter, 1985). Detection limits at the Illinois Laboratory were 0.02 ppm for brodifacoum and bromadiolone; 0.03 ppm for difenacoum; 0.05 ppm for coumatetralyl; 0.1 ppm for warfarin, fumarin, and coumachlor; 0.02 ppm for diphacinone; 0.4 ppm for pindone and valone; and 0.5 for 4, 6, 7 and 8-OH warfarin.

## RESULTS

Death from hemorrhage associated with anticoagulant rodenticides was confirmed in 51 cases (56 individual animals) over a 27 yr period (Table 1). Only three cases, all involving warfarin, were diagnosed pri-

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TABLE 1. Anticoagulant rodenticide poisonings in wildlife in New York (USA) and adjoining states, 1971–1997.

| | Species[a] | Date (Mo/yr) | County[b] | Gross pathology[c] | Toxicant (ppm in liver) | updates to |
|---|---|---|---|---|---|---|
| | Gray squirrel | 10/71 | Westchester | d | warfarin (not quantified) | I006306-010 |
| | Gray squirrel | 9/81 | Niagara | b, d, k | warfarin (0.228) | |
| | Peregrine falcon | 10/86 | Cape May | c, d, h | warfarin (1.48) | I006306-016 |
| | Great horned owl | 3/89 | Putnam | a, b | brodifacoum (0.01) | |
| | Great horned owl | 10/89 | Suffolk | a, b | brodifacoum (0.2) | |
| | Gray squirrel | 5/90 | Westchester | a, h | brodifacoum (0.7) | |
| | Gray squirrel | 7/90 | Monroe | b, l | brodifacoum (4.1) | |
| | Eastern chipmunk | 6/92 | Albany | a, b | brodifacoum (3.8) | |
| | Raccoon | 6/92 | Niagara | j | brodifacoum (1.8 in stomach contents) | |
| | Raccoons (3) | 9/92 | Nassau | c | brodifacoum (3.1, 5.3, 4.6) | |
| | Gray squirrel | 8/93 | Albany | a, d, h | brodifacoum (0.53), chlorofacinone (0.62) | |
| | Gray squirrel | 9/93 | Albany | a, d, j | brodifacoum (25.8 in colon contents) | |
| | Snowy owl | 11/93 | Dutchess | a, d | diphacinone (0.26) | |
| | Great horned owl | 3/94 | Niagara | b, h | brodifacoum (0.53) | |
| | Great horned owl | 6/94 | Albany | a, b, f, g | brodifacoum (0.64) | |
| | White-tailed deer | 10/94 | Suffolk | c, i | brodifacoum (0.38) | updates I006306-031 |
| | Great horned owl | 10/94 | Erie | a, b, f | brodifacoum (0.41) | |
| | Red-tailed hawk | 11/94 | Westchester | b, g, f | brodifacoum (0.41) | |
| | Great horned owl | 11/94 | Orleans | a, b, e, f, g | brodifacoum (0.73) | |
| | Great horned owl | 12/94 | Albany | a, b, d, f, g | brodifacoum (0.1) | |
| | Red-tailed hawk | 12/94 | Westchester | a, b, f | brodifacoum (0.23) | |
| | Red-tailed hawk | 1/95 | Richmond | b, h | brodifacoum (0.43) | |
| | Red-tailed hawk | 3/95 | Nassau | b, g | brodifacoum (0.76) | |
| | Bald eagle | 4/95 | Orleans | i | warfarin (1.4) | |
| | Great horned owl | 8/95 | Suffolk | a, d, h | brodifacoum (0.53), bromadiolone (0.14) | updates |
| | White-tailed deer | 9/95 | Suffolk | c, d, e | brodifacoum (0.37), coumatetralyl (0.5) | I003088-001 & |
| | Red-tailed hawk | 12/95 | Suffolk | a, b, f, g | brodifacoum (1.6) | I003909-010 |
| | Great horned owl | 2/96 | Chenango | a, h, i | brodifacoum (0.36) | |
| | Raccoon | 3/96 | Suffolk | a, d, e, j | brodifacoum (1.0) | |
| | Red fox (2) | | | b, c, e | brodifacoum (1.32 and 4.01) | |
| | Skunks (3) | 4/96 | Westchester | a, c, e | bromadiolone (0.02, 0.28, 0.08) | |
| | Raven | 4/96 | Rensselaer | a, d, h | brodifacoum (1.04) | |
| | Golden eagle | 4/96 | Monroe | c | brodifacoum (0.03) | probably update |
| | White-tailed deer | 4/96 | Suffolk | c, e | brodifacoum (0.12) | I003597-001 |
| | White-tailed deer | 5/96 | Suffolk | c, k | brodifacoum (0.41) | probably updates |
| | Red-tailed hawk | 6/96 | Onondaga | a, b, f, g | brodifacoum (0.65) | I006306-025; I003597? |
| | Great horned owl | 6/96 | Monroe | a, b, d, e, g | brodifacoum (0.35) | I003598? |
| | White-tailed deer | 10/96 | Suffolk | c, e | diphacinone (0.93) | |
| | Red-tailed hawk | 10/96 | Suffolk | b, i | brodifacoum (0.5) | |
| | Opossum | 11/96 | Albany | e | bromadiolone (0.8) | |
| I013798 | White-tailed deer | 12/96 | Suffolk | c | diphacinone (0.2) | |
| | Gray squirrel | 12/96 | Albany | a, b, d | brodifacoum (1.39) | |
| -002 | Common crow | 1/97 | Fairfield | a, d, f, l | brodifacoum (1.34) | |
| | Screech owl | 2/97 | Suffolk | a, c | brodifacoum (0.34) | |
| | Great horned owl | 2/97 | Greene | a, b, f | brodifacoum (0.08) | |
| | Raccoon | 3/97 | Albany | a, d, f, l | brodifacoum (0.32) | |
| | Gray squirrel | 4/97 | Suffolk | a, e | diphacinone (2.0) | |
| | Opossum | 4/97 | Albany | e | brodifacoum (0.18) | |
| | Great horned owl | 4/97 | Niagara | ( | brodifacoum (0.11) | |
| | Great horned owl | 6/97 | Dutchess | b, g | brodifacoum (0.22) | |
| | Screech owl | 10/97 | Erie | d | brodifacoum (0.80) | |
| | White-tailed deer | 12/97 | Suffolk | a, c, e | brodifacoum (0.16) | |

[a] See text for scientific names.

[b] All in New York except for Cape May (New Jersey) and Fairfield (Connecticut).

[c] a = subcutaneous hemorrhage; b = pallor of muscle and/or internal organs; c = hemorrhage in lungs; d = inter- and intramuscular hemorrhages; e = subcutaneous edema; f = low blood volume heart/major vessels; g = excessive hemorrhage from superficial wounds; h = free hemorrhage or bloody fluid in body cavity; i = hemorrhage into alimentary canal; j = dyed rodenticide bait in alimentary canal; k = hemorrhage and/or serum in pericardial sac; l = intrauterine hemorrhage.

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